TECHNOLOGY TRANSFER PROGRAM (TTP)

FINAL REPORT

COST ACCOUNTING

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FINAL REPORT

Prepared by:

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in conjunction with:
I HI Marine Technology Inc.

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PREFACE

This report is one of several emanating from-the Shipbuilding Technology Transfer Program performed by Livingston Shipbuilding Company under a cost-sharing contract with the U.S. Maritime Administration.

The material contained herein was developed from the study of the Cost Accounting systems presently in operation in the shipyards of Ishikawajima-Harima Heavy Industries (IHI) of Japan. Information for this study was derived from source documentation supplied by IHI, information obtained directly from IHI consulting personnel assigned on-site at Livingston, and from personal observations by two teams of Livingston personnel of actual operations at various IHI shipyards in Japan.

The original data on which this report is based contains cost information proprietary to either Livingston Shipbuilding Company or Ishikawajima-Harima Heavy Industries Company, Ltd., (IHI). The data contained in this report have therefore been edited to remove significant quantitative values, whether manhours, material values in dollars or yen, manhours per ton or whatever. The report has, however, been written throughout in such a way as to retain the significance of its analyses despite this apparent emasculation. This is achieved by relating every quantitative value to one of a number of common baselines, expressing each eliminated value as a proportion of one or more relevant total values. In this way comparisons can be made between values without compromising the confidentiality of either LSOC's or IHI's costs.

In order to place this study in context within the overall Technology Transfer Program, a brief overview of the program and its organization is provided in the following paragraphs.

THE TECHNOLOGY TRANSFER PROGRAM (TTP)

The U.S. shipbuilding industry is well aware of the significant shipbuilding cost differences between the Japanese and ourselves. Many reasons have been offered to explain this differential and whether the reasons are valid or not, the fact remains that Japanese yards are consistently able to offer ships at a price of one-half to two-thirds below the U.S. prices.

Seeing this tremendous difference first hand in their own estimate of a bulk carrier slightly modified from the IHI "Future-32" class design, Livingston management determined not only to find out why this was true but also to attempt to determine precise differences between IHI and Livingston engineering and design practices; production planning and control methods; facilites, production processes, methods and techniques; quality assurance methods; and personnel organization, operations and training. The obvious objective of such studies was to identify, examine and implement the Japanese systems, methods and processes which promised a significant improvement in the Livingston design/production process.

With this objective in mind, and recognizing the potential application of the TTP results to the American shipbuilding industry, Livingston initiated a cost-sharing contract with MarAd to provide documentation and industry seminars to reveal program findings and production improvement results measured during production of the

bulkers. At the same time, Livingston subcontracted with IHI marine Technology Inc. (an American corporation and a subsidiary of IHI, Japan) specifying the areas to be explored and the number and type of IHI consulting personnel required during the period of re-design and initial construction of the first bulker.

Basically, the program is organized into six major tasks:

1 - Cost Accounting

2- Engineering and Design

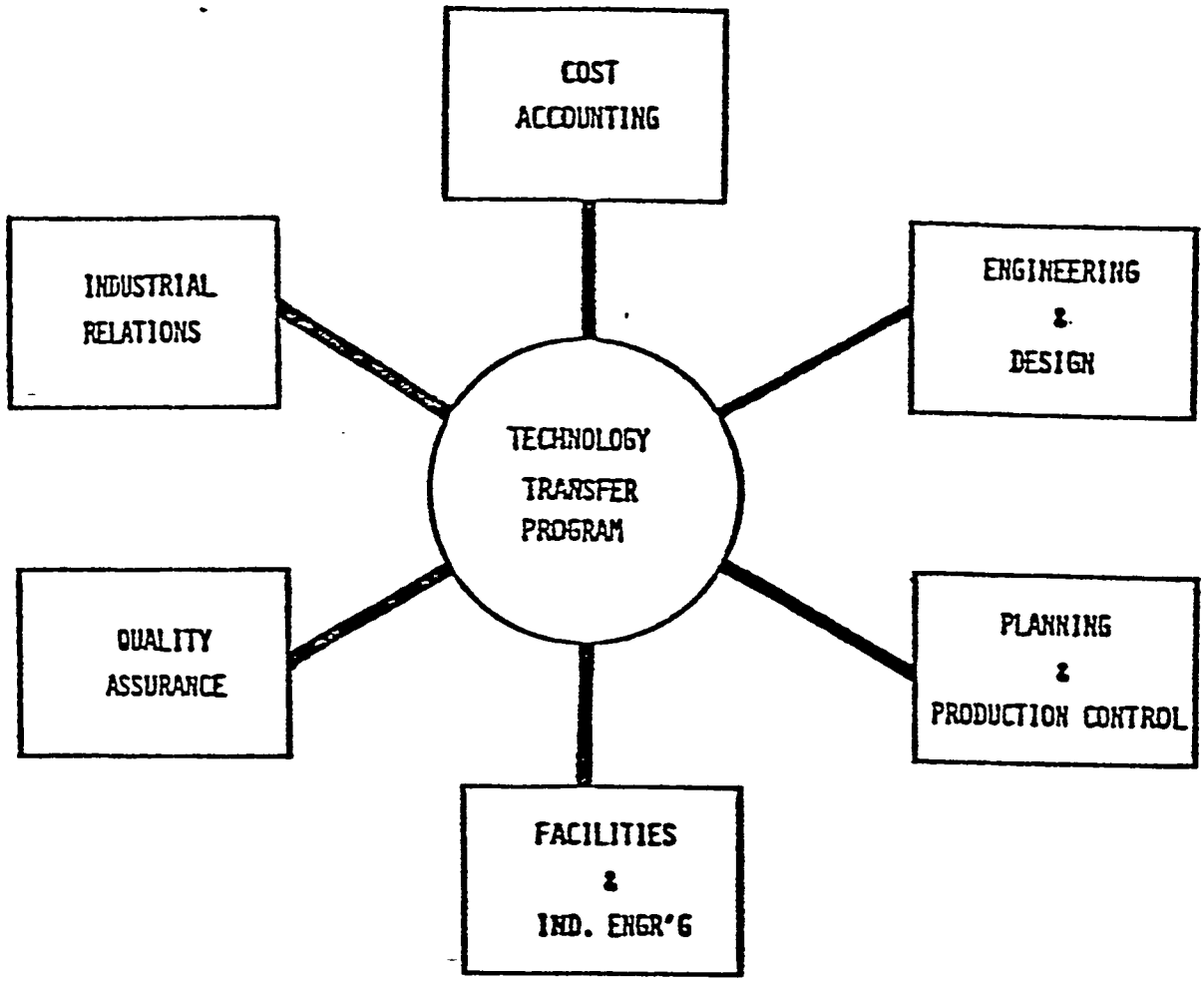
3- Planning and Production Control

4- Facilities and Industrial Engineering

5- Quality Assurance

6- Industrial Relations

Beneath each of these major tasks is a series of sub-tasks which further delineate discrete areas of investigation and study. Each sub-task area has been planned and scheduled to: 1) study IHI systems, methods and techniques; 2) compare the Livingston and IHI practices; 3) identify improvements to the Livingston systems; 4) implement approved changes; 5) document program findings, changes to the Livingston systems, and the results of those changes; and 6) disseminate program findings and results to industry via MarAd.


COST
ACCOUNTING
INDUSTRIAL
RELATIONS
ENGINEERING
&
DESIGN
TECHNOLOGY
TRANSFER
PROGRAM
QUALITY
ASSURANCE
PLANNING
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SECTION 1

INTRODUCTION AND METHODOLOGY

This report is an account of the results of work performed in the first study area of the Shipbuilding Technology Transfer program, entitled "Cost Accounting". It is structured in four sections, of which this Introduction is the first.

Injection 2, a comparison is made between LSCO's estimated costs for me first ship in its current series and IHI's actual costs for the first Future-32 ship built at its Aioi shipyard, modified to allow for design variations. The comparison is made in the context of LSCO's cost accounting system. The differences in manhours and material costs for each account are identified, adjusted to a common baseline and ranked in order of significance.

In Section 3, the difference between the two companies' cost accounting and control systems are described and reviewed for potentially desirable benefits.

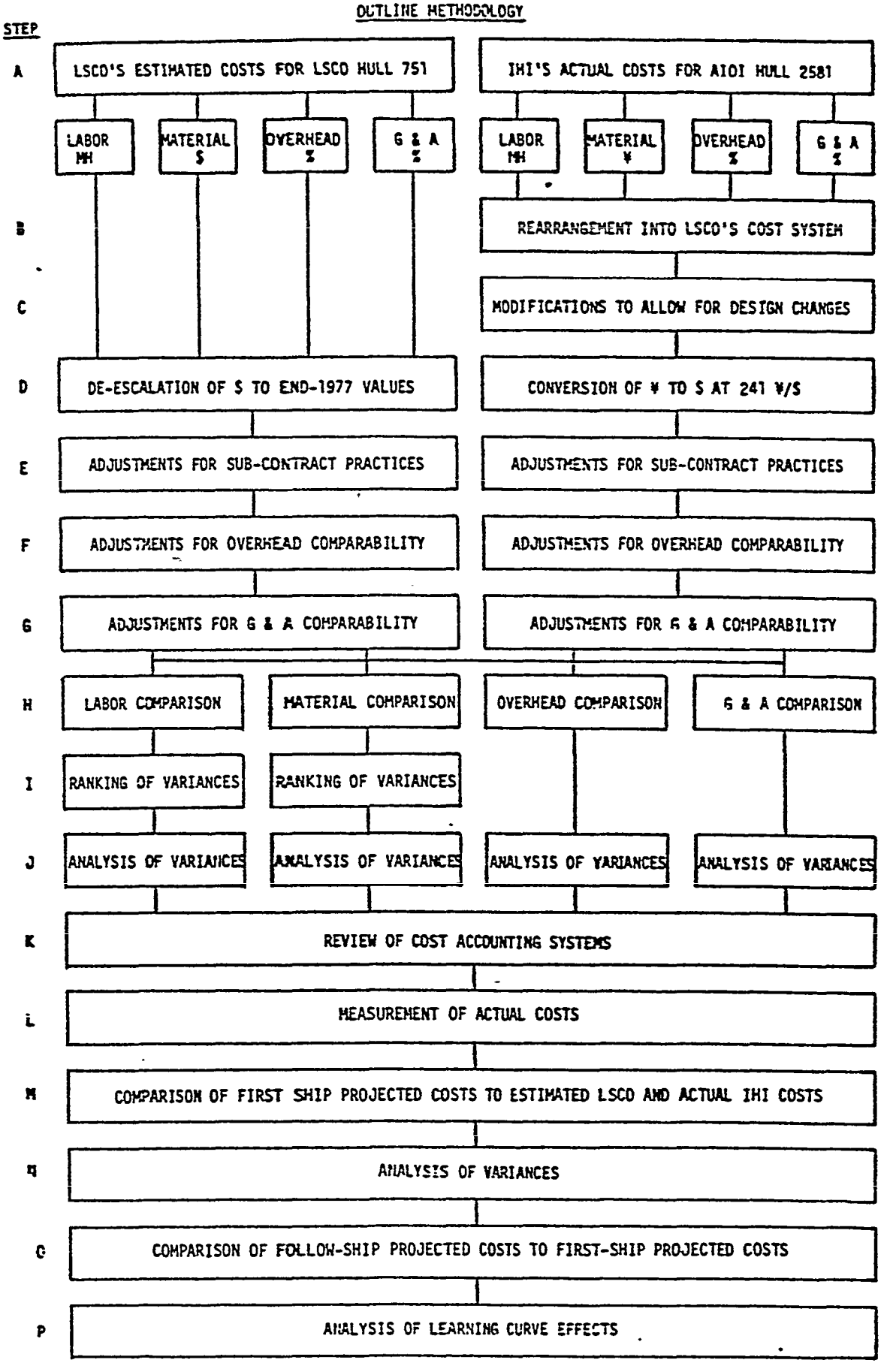
Finally, in Section 4, a further comparison is made between the two sets of cost data presented in Section 2 and the actual costs incurred by LSCO in the construction of the first ship in the series. The analysis contained in this section also covers the projected costs at completion of the second and third ships of the series, in order to evaluate early learning curve effects.

The techniques used in this report to allow comparability of the two sets of numbers have been kept as simple as possible. The basic methodology is shown in the flow chart presented in Exhibit 1-1 and described below, step by step.

Step A: Definition of baseline COStS, estimated costs for the first LSCO ship on the one hand and actual costs for the first IHI-Aioi ship on the other, without any modification or adjustment. The LSCO baseline was developed by LSCO's Estimating Departmental part of their normal duties: the IHI baseline was provided by IHI Aioi from actual cost accounting returns.

EXHIBIT I-1

OUTLINE METHODOLOGY



Step B: Re-arrangement of IHI's baseline costs into the LSCo cost accounting system to provide direct item-by-item comparability. This was accomplished by IHI's cost engineer with help from a LSCo cost accountant and required a review of the detailed sub-accounts in each of IHI's cost accounts and the assignment of those costs to the appropriate LSCo cost account. No adjustments were made in this process. for direct comparability of sub-contract work or differences in indirect accounting. The bottom-line totals of manhours and material costs were unchanged from the previous step.

Step C: Modification of IHI's costs to reflect design changes applied to the IHI design for construction in a U.S. yard. These adjustments were initially applied to the material quantities by IHI engineers working on the design changes under LSCo's separate design contract with IMT. The IHI cost engineer assigned to this task then re-estimated manhours and material costs.

Step D: Conversion of currencies and adjustment for the time value of money. IHI's actual costs were incurred in the first quarter of 1977 and were therefore converted to dollars at the average exchange rate prevailing at that time, which was 241 yen per dollar. LSCO's estimated costs were calculated on the basis of costs prevailing in September of 1978. (Escalation was provided for separately in developing the full contract price for LSCo's ships.) Because of the significant differences between the exchange rates in the two periods; it was decided to de-escalate LSCo's estimated costs to March 1977 levels rather than escalate IHI's costs. This was done on a historical basis for steel, using actual prices, while for other items various industrial commodities price indexes were used.

Step E: Adjustments were made for differences between sub-contracting practices in the two shipyards. IHI sub-contracts work to a much greater extent than LSCo and it was generally possible to convert an IHI sub-contract cost to

equivalent labor manhours and material dollars, especially for those items which were pure labor.

Step F: Adjustments were made for differences between IHI and LSCo overhead accounting practices. Costs were transferred where possible from overhead accounts to direct accounts for maximum comparability, but in some cases it was not possible to define or to estimate a particular overhead cost item and it was necessary to transfer a direct cost to overhead.

Step G: Adjustments of a similar nature were made for differences between IHI and LSCo G and A accounting practices.

The two adjusted cost breakdowns were then comparable on an item-by-item basis.

Step H: Direct comparison between labor and material costs was made on an item-by-item basis and with reference to one or more common totals. Thus labor manhours for a particular item were compared and IHI's manhours expressed as a proportion of LSCO's, but, in addition, both values were expressed as proportions of total group costs such as hull steel, outfitting, etc., and as proportions of total ship costs. A similar comparison was made for material-costs.

Step I: Labor and material costs were ranked, item-by-item, in ascending order of the size of the ratio of IHI's cost *to* LSCo's.

Step J: Analysis of the significant cost differences was made for labor manhours and material costs separately, to identify as much as possible the reasons for them.

Step K: A review of cost accounting systems at LSCo and IHI provided insight into the differences between the two shipyards' approaches to costing.

Step L: During the course of the ship construction program, actual costs were recorded and periodically compared to the estimated costs, as is normal in any industrial operation. Particular attention, however, was paid in this program to the items identified in this report as having significant variances and

to those covering areas of activity in which significant changes have been or are being implemented in the shipyard. In this way the trends in actual costs were recorded as well as the actual costs themselves.

Step M: When the first ship was almost complete, final actual manhours and material costs were compared to both the estimated values and IHI's first-ship actual costs in the same way as in Step H.

Step N: A variance analysis was then conducted in the same way as in Step J.

Step O: As the construction program progressed, follow ship costs were also recorded and compared, as in Step L. In this report the projected costs at completion of the second and third ships were compared to LSCo's first ship actual costs, as in Steps M and N.

Step P: To the extent that sufficient data were available, an analysis of learning curve effects was undertaken.

Because of the relatively large number of items being considered, even at this summary level, comparative values have been expressed as proportions rather than percentages; i.e., as .0318 rather than as 3.18%. Care has been taken throughout to relate these proportions to their total, using simple abbreviations and symbols, as shown in the following examples:

Syllbol	Meaning
IL	Total labor manhours at IHI
IL_{HU}	Sub-total hull labor manhours at IHI
IL_{31}	Sub-total Item 31 manhours at IHI
LM	Total material dollars at LSCo
LM_{HU}	Sub-total hull material dollars at LSCo
LM_{31}	Sub-total Item 31 material dol1ars at LSCo

In this way a relationship can be easily expressed in an intelligible way without lengthy verbalizing. We may say, for example, that IHI's material costs on Item 25 are related to other relevant values according to the following expression, which would take half a page to put into words:

$$IM_{25} = .7825\ LM_{25} = .2515\ IM_{HU} = .2650\ LM_{HU} = .0623\ IM = .0586\ LM$$

SECTION 2

DEVELOPMENT OF COMPARABLE COSTS

LSCo uses a four-digit cost accounting system comprising a total of 62 two-digit items and 314 four-digit sub-items. Estimates are prepared at the item level only and are broken down by sub-item and department only in the budgeting process. This study is confined to the two-digit item level.

IHI also uses a four-digit material cost accounting system but it is structured rather differently from LSCo'S. IHI records its direct labor costs by process, without reference to the accounts used for material and this system is also very different from LSCO's.

2.1 Labor Costs (Steps A, B and C)

In Step A, the baseline direct labor manhours estimated by LSCo for the first ship in its program were tabulated and are presented here as Exhibit II-1. The baseline actual direct labor manhours recorded by IHI for the first Future-32 built at their Aioi shipyard were tabulated and are presented here in IHI's cost breakdown system in Exhibit II-2.

In Step B, IHI's baseline actual direct labor manhours for their first sh are re-arranged in the LSCo cost system: this is presented here in Exhibit II-3.

In Step C, IHI's baseline actual direct labor manhours for their f ship are modified to allow for the design changes required for U.S. construction: this is presented in Exhibit II-4.

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EXHIBIT II-1

BASELINE ESTIMATED DIRECT LABOR MANHOURS

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	.0019
03	Building Ways and Launching	.0151
05	Mold Loft	.0184
06	Warehousing	.0045
07	Construction Services	.0208
08	Clean Up	.0467
09	Testing and Inspection	.0288
11	Insurance, Christening, etc.	.0009
Sub-total	Preliminary Items	.1370
01	Engineering	.0454
02	Planning and Production Control	.0133
85	Supervision	.0941
Sub-total	Staff Items	.1528
13	Hull Bottom	.0246
15	Hull Bulkheads and Framing	.2077
17	Hull Sides and Attachments	.0506
21	Hull Decks and Flats	.0252
23	Hull Inner Bottom	.0567
27	Bulworks and Windbreaks	.0044
37	Deckhouses	.0355
87	Steel Scrap	-
89	Welding Supplies	-
Sub-total	Hull Steel Items	.4049
19	Miscellaneous Hull Structure	.0004
25	Foundations and Tanks	.0138
33	Deck Fittings	.0046
35	Ladders below Deck	.0177
55	Ladders above Deck	.0074
73	Doors and Hatches	.0218
75	Benches and Shelving	.0052
77	Awnings	-
Sub-total	Minor Steel Items	.0708
29	Sternframe and Sterntube	.0072
31	Rudder	.0085
45	Port Lights and Windows	.0018
57	Derricks and Cranes	.0161
61	Steering Systems	.0014
63	Propellers and Shafting	.0047
65	Machinery and Equipment	.0219
69	Mooring Equipment	.0043
71	Safety Requirements	.0025
Sub-total	Machinery Items	.0685
39	Quarters Outfit	.0026
67	Heating, Ventilation & Air Conditioning	.0044
79	Electrical Systems	.0431
81	Blasting and Painting	.0616
83	Piping Systems	.0544
Sub-total	Outfitting Items	.1661
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	.2898
Sub-total	All Steel Items	.4756
Sub-total	All Outfitting Items	.2346
TOTAL	All Items	1.0000

A-01 EXHIBIT II-2

BASELINE ACTUAL DIRECT LABOR MANHOURS

Process	Proportion
Mold Loft	.0554
Fabrication	.1254
Assembly	.2123
Erection	.1035
Services	.0666
Sub-total, Hull Construction	.5632
Deck Items	.0593
Accommodation	.0721
Pipe Fabrication	.0358
Painting	
Machinery	.0838
Electric	.0437
Other	.0328
Sub-total, Fitting	.4368
Total, All Processes	1.0000

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EXHIBIT II-3

BASELINE ACTUAL DIRECT LABOR MANHOURS

(RE-ARRANGED IN THE LSCO SYSTEM)

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	.0025
03	Building Ways and Launching	.0130
05	Mold Loft	.0421
06	Warehousing	.0304
07	Construction Services	.0487
08	Clean Up	-
09	Testing and Inspection	.0125
11	Insurance, Christening, etc.	-
Sub-total	Preliminary Items	.1493
01	Engineering	-
02	Planning and Production Control	.0133
85	Supervision	-
Sub-total	Staff Items	.0133
13	Hull Bottom	.0538
15	Hull Bulkheads and Framing	.0829
17	Hull Sides and Attachments	.1139
21	Hull Decks and Flats	.0842
23	Hull Inner Bottom	.0733
27	Bulworks and Windbreaks	.0041
37	Deckhouses	.0467
87	Steel Scrap	-
89	Welding Supplies	-
Sub-total	Hull Steel Items	.4589
19	Miscellaneous Hull Structure	.0017
25	Foundations and Tanks	.0095
33	Deck Fittings	.0015
35	Ladders below Deck	.0126
55	Ladders above Deck	.0043
73	Doors and Hatches	.0127
75	Benches and Shelving	.0014
77	Awnings	-
Sub-total	Minor Steel Items	.0438
29	Sternframe and Sterntube	.0005
31	Rudder	.0023
45	Port Lights and Windows	.0026
57	Derricks and Cranes	.0047
61	Steering Systems	.0022
63	Propellers and Shafting	.0030
65	Machinery and Equipment	.0123
69	Mooring Equipment	.0038
71	Safety Requirements	.0010
Sub-total	Machinery Items	.0323
39	Quarters Outfit	.0390
67	Heating, Ventilation & Air Conditioning	.0097
79	Electrical Systems	.0393
81	Blasting and Painting	.1092
83	Piping Systems	.1051
Sub-total	Outfitting Items	.3024
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	.1626
Sub-total	All Steel Items	.5026
Sub-total	All Outfitting Items	.3347
TOTAL	All Items	1.0000

step C

EXHIBIT II-4

MODIFIED ACTUAL DIRECT LABOR MANHOURS

(MODIFIED FOR DESIGN CHANGES)

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	.0023
03	Building Ways and Launching	.0120
05	Mold Loft	.0389
06	Warehousing	.0281
07	Construction Services	.0450
08	Clean Up	-
09	Testing and Inspection	.0115
11	Insurance, Christening, etc.	-
Sub-total	Preliminary Items	.1378
01	Engineering	-
02	Planning and Production Control	.0123
85	Supervision	-
Sub-total	Staff Items	.0123
13	Hull Bottom	.0298
15	Hull Bulkheads and Framing	.1551
17	Hull Sides and Attachments	.0815
21	Hull Decks and Flats	.0478
23	Hull Inner Bottom	.0806
27	Bulworks and Windbreaks	.0020
37	Deckhouses	.0431
87	Steel Scrap	-
89	Welding Supplies	-
Sub-total	Hull Steel Items	.4400
19	Miscellaneous Hull Structure	.0017
25	Foundations and Tanks	.0123
33	Deck Fittings	.0015
35	Ladders below Deck	.0135
55	Ladders above Deck	.0040
73	Doors and Hatches	.0111
75	Benches and Shelving	.0013
77	Awnings	-
Sub-total	Minor Steel Items	.0454
29	Sternframe and Sterntube	.0003
31	Rudder	.0021
45	Port Lights and Windows	.0024
57	Derricks and Cranes	.0084
61	Steering Systems	.0020
63	Propellers and Shafting	.0044
65	Machinery and Equipment	.0169
69	Mooring Equipment	.0035
71	Safety Requirements	.0009
Sub-total	Machinery Items	.0410
39	Quarters Outfit	.0476
67	Heating, Ventilation & Air Conditioning	.0100
79	Electrical Systems	.0472
81	Blasting and Painting	.1175
83	Piping Systems	.1012
Sub-total	Outfitting Items	.3236
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	.1501
Sub-total	All Steel Items	.4854
Sub-total	All Outfitting Items	.3646
TOTAL	All Items	1.0000

2.2 Material Costs (Steps A, B, C and D)

In Step A, the baseline direct material dollars estimated by LSCo for the first ship in its program were tabulated and are presented here as Exhibit II-5. The baseline actual direct material costs in yen recorded by IHI for the first Future-32 built at their Aioi shipyard were tabulated and are presented in IHI's cost breakdown system in Exhibit II-6.

In Step B, IHI's baseline actual direct material yen for their first ship are re-arranged in the LSCo cost system: this is presented here in Exhibit II-7.

In Step C, IHI's baseline actual direct material yen for their first ship are converted into dollars at the exchange rate current in March, 1977: this is presented here in Exhibit II-8.

In Step D, LSCo'S baseline estimated direct material dollars for their first ship are de-escalated from September, 1978 values to March, 1977 values, according to factors established in Exhibit II-9; the results are presented in Exhibit 11-10. Also in Step D, IHI's baseline direct material dollars are modified to allow for the design changes required for U.S. construction: this is presented here in Exhibit II-11.

LSCO

EXHIBIT II-5

BASELINE ESTIMATED DIRECT MATERIAL COSTS

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	.0332
03	Building Ways and Launching	.0067
05	Mold Loft	.0029
06	Warehousing	.0026
07	Construction Services	.0064
08	Clean Up	.0006
09	Testing and Inspection	.0026
11	Insurance, Christening, etc.	.0360
Sub-total	Preliminary Items	.0912
01	Engineering	.0939
02	Planning and Production Control	-
85	Supervision	-
Sub-total	Staff Items	.0939
13	Hull Bottom	.0114
15	Hull Bulkheads and Framing	.0570
17	Hull Sides and Attachments	.0253
21	Hull Decks and Flats	.0188
23	Hull Inner Bottom	.0334
27	Bulworks and Windbreaks	.0005
37	Deckhouses	.0092
87	Steel Scrap	.0159
89	Welding Supplies	.0149
Sub-total	Hull Steel Items	.1864
19	Miscellaneous Hull Structure	.0002
25	Foundations and Tanks	.0009
33	Deck Fittings	.0036
35	Ladders below Deck	.0016
55	Ladders above Deck	.0012
73	Doors and Hatches	.0551
75	Benches and Shelving	.0005
77	Awnings	.0001
Sub-total	Minor Steel Items	.0631
29	Sternframe and Sterntube	.0046
31	Rudder	.0021
45	Port Lights and Windows	.0029
57	Derricks and Cranes	.0238
61	Steering Systems	.0063
63	Propellers and Shafting	.0124
65	Machinery and Equipment	.2445
69	Mooring Equipment	.0317
71	Safety Requirements	.0144
Sub-total	Machinery Items	.3427
39	Quarters Outfit	.0674
67	Heating, Ventilation & Air Conditioning	.0169
79	Electrical Systems	.0645
81	Blasting and Painting	.0193
83	Piping Systems	.0545
Sub-total	Outfitting Items	.2227
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	.1850
Sub-total	All Steel Items	.2495
Sub-total	All Outfitting Items	.5654
TOTAL	All Items	1.0000

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EXHIBIT 11-6

BASELINE ACTUAL DIRECT MATERIAL COSTS

ITEM #	DESCRIPTION	PROPORTION
10	Standard Material	.0001
11	Hull Steel	.2328
14	Electrodes	.0166
16	Large Castings & Forgings	.0244
Sub-total	Hull	.2740
20	Standard Material	.0133
21	Woodwork	.0004
22	Deck Coverings	.0036
23	Paint & Anodes	.0204
24	Navigation & Communication	.0037
25	Mooring Gear	.0119
26	Masts & Hatches	.0788
27	Miscellaneous Outfit	.0209
28	Lighting & Ventilation	.0043
29	Hull Piping	.0103
32	Piping Controls	.0039
33	Refrigeration	.0017
34	Joiner Work	.0087
35	Living Quarters	.0339
36	Deck Machinery	.1018
37	Other Material	.0027
39	Supplemental Material	.0016
Sub-total	Outfit	.3219
40	Standard Material	.0199
41	Main Engine	.1853
42	Boiler	.0106
43	Shaft & Propeller	.0241
44	Auxiliaries	.0344
45	Funnel & Stack	.0053
46	Piping	.0038
47	Instrumentation	.0024
48	Other Outfit	.0190
49	Supplemental Material	.0091
Sub-total	Machinery	.3139
50	Standard Material	.0008
51	Generators & Distribution	.0434
52	Secondary Power	.0012
53	Lighting & Signals	.0048
54	Navigation, Communication Controls	.0108
55	Miscellaneous	.0023
56	Cable	.0088
57	Accessories	.0045
58	Wireless	.0135
59	Supplemental Material	.0001
Sub-total	Electrical	.0902
Total	All Items	1.0000

EXHIBIT II-7

BASELINE ACTUAL DIRECT MATERIAL COSTS

(RE-ARRANGED IN THE LSCO SYSTEM)

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	-
03	Building Ways and Launching	-
05	Mold Loft	-
06	Warehousing	-
07	Construction Services	-
08	Clean Up	-
09	Testing and Inspection	-
11	Insurance, Christening, etc.	-
Sub-total	Preliminary Items	-
01	Engineering	-
02	Planning and Production Control	-
85	Supervision	-
Sub-total	Staff Items	-
13	Hull Bottom	..0301
15	Hull Bulkheads and Framing	.0446
17	Hull Sides and Attachments	.0508
21	Hull Decks and Flats	.0455
23	Hull Inner Bottom	.0446
27	Bulworks and Windbreaks	.0015
37	Deckhouses	.0157
87	Steel Scrap	-
89	Welding Supplies	.0176
Sub-total	Hull Steel Items	.2505
19	Miscellaneous Hull Structure	.0007
25	Foundations and Tanks	.0163
33	Deck Fittings	.0008
35	Ladders below Deck	.0029
55	Ladders above Deck	.0018
73	Doors and Hatches	.0799
75	Benches and Shelving	.0026
77	Awnings	.0001
Sub-total	Minor Steel Items	.1050
29	Sternframe and Sterntube	.0136
31	Rudder	.0129
45	Port Lights and Windows	.0017
57	Derricks and Cranes	.0772
61	Steering Systems	.0040
63	Propellers and Shafting	.0224
65	Machinery and Equipment	.2665
69	Mooring Equipment	.0266
71	Safety Requirements	.0132
Sub-total	Machinery Items	.4381
39	Quarters Outfit	.0529
67	Heating, Ventilation & Air Conditioning	.0113
79	Electrical Systems	.0593
81	Blasting and Painting	.0197
83	Piping Systems	.0540
Sub-total	Outfitting Items	.1972
	Unassigned Items	.0093
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	-
Sub-total	All Steel Items	.3454
Sub-total	All Outfitting Items	.6546
Total	All Items	1.0000

EXHIBIT II-8

BASELINE ACTUAL DIRECT MATERIAL COSTS

(CONVERTED TO DOLLARS @ ¥241/$)

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	-
03	Building Ways and Launching	-
05	Mold Loft	-
06	Warehousing	-
07	Construction Services	-
08	Clean Up	-
09	Testing and Inspection	-
11	Insurance, Christening, etc.	-
Sub-total	Preliminary Items	-
01	Engineering	-
02	Planning and Production Control	-
85	Supervision	-
Sub-total	Staff Items	-
13	Hull Bottom	.0301
15	Hull Bulkheads and Framing	.0446
17	Hull Sides and Attachments	.0508
21	Hull Decks and Flats	.0455
23	Hull Inner Bottom	.0446
27	Bulworks and Windbreaks.	.0015
37	Deckhouses	.0157
87	Steel Scrap	-
89	Welding Supplies	.0176
Sub-total	Hull Steel Items	.2505
19	Miscellaneous Hull Structure	.0007
25	Foundations and Tanks	.0163
33	Deck Fittings	.0008
35	Ladders below Deck	.0029
55	Ladders above Deck	.0018
73	Doors and Hatches	.0799
75	Benches and Shelving	.0026
77	Awnings	.0001
Sub-total	Minor Steel Items	.1050
29	Sternframe and Sterntube	.0136
31	Rudder	.0129
45	Port Lights and Windows	.0017
57	Derricks and Cranes	.0772
61	Steering Systems	.0040
63	Propellers and Shafting	.0224
65	Machinery and Equipment	.2665
69	Mooring Equipment	.0266
71	Safety Requirements	.0132
Sub-total	Machinery Items	.4381
39	Quarters Outfit	.0529
67	Heating, Ventilation & Air Conditioning	.0113
79	Electrical Systems	.0593
81	Blasting and Painting	.0197
83	Piping Systems	.0540
Sub-total	Outfitting Items	.1972
	Unassigned Items	.0093
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	-
Sub-total	All Steel Items	.3454
Sub-total	All Outfitting Items	.6546
Total	All Items	1.0000

EXHIBIT II-9

DE-ESCALATION FACTORS

ITEM #	DESCRIPTION	INDEX USED	INDEX 9/78	VALUE 3/77	DE-ESCALATION FACTOR
00 Thru 11	Preliminary Items	Industrial Commodities	212.5	191.7	0.9021
13 thru 27,31, 33,35,37,55, 87,89	Steel Items	Steel Prices	$400/ton	$360/ton	0.9000
29,	Sternframe & Tube	Foundry Products	253.6	225.7	0.8900
39	Quarters Outfitting	Industrial Commodities	212.5	191.7	0.9021
45,73,75,77	General Outfitting	Industrial Commodities	212.5	191.7	0.9021
57,61,63,65 67,69,71	Outfitting-Machinery and Equipment	Gen. Purpose Machinery & Equiptment	219.7	197.5	0.8990
79	Electrical Systems	Electrical Machinery & Equipment	166.4	151.9	0.9129
		Copper Wire & Cable	147.2	150.6	1.0231
					0.9680
81	Blasting & Painting	Prepared Paint	192.6	178.9	0.9289
83	Piping Systems	Pipe	285.5	239.9	0.8403
		Valves & Flanges	235.0	213.6	0.9089
					0.8746

EXHIBIT II-10

BASELINE ESTIMATED DIRECT MATERIAL COSTS

(DE-ESCALATED TO MARCH 1977 VALUES)

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	.0332
03	Building Ways and Launching	.0067
05	Mold Loft	.0028
06	Warehousing	.0026
07	Construction Services	.0064
08	Clean Up	.0006
09	Testing and Inspection	.0026
11	Insurance, Christening, etc.	.0360
Sub-total	Preliminary Items	.0910
01	Engineering	.0937
02	Planning and Production Control	-
85	Supervision	-
Sub-total	Staff Items	.0937
13	Hull Bottom	.0114
15	Hull Bulkheads and Framing	.0567
17	Hull Sides and Attachments	.0252
21	Hull Decks and Flats	.0187
23	Hull Inner Bottom	.0333
27	Bulworks and Windbreaks	.0005
57	Deckhouses	.0091
87	Steel Scrap	.0158
89	Welding Supplies	.0149
Sub-total	Hull Steel Items	.1856
19	Miscellaneous Hull Structure	.0002
25	Foundations and Tanks	.0009
33	Deck Fittings	.0036
35	Ladders below Deck	.0016
55	Ladders above Deck	.0012
73	Doors and Hatches	.0550
75	Benches and Shelving	.0005
77	Awnings	.0001
Sub-total	Minor Steel Items	.0630
29	Sternframe and Sterntube	.0045
31	Rudder	.0021
45	Port Lights and Windows	.0029
57	Derricks and Cranes	.0237
61	Steering Systems	.0063
63	Propellers and Shafting	.0123
65	Machinery and Equipment	.2432
69	Mooring Equipment	.0315
71	Safety Requirements	.0144
Sub-total	Machinery Items	.3409
39	Quarters Outfit	.0673
67	Heating, Ventilation & Air Conditioning	.0168
79	Electrical Systems	.0691
81	Blasting and Painting	.0199
83	Piping Systems	.0527
Sub-total	Outfitting Items	.2258
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	.1847
Sub-total	All Steel Items	.2486
Sub-total	All Outfitting Items	.5667
TOTAL	All Items	1.0000

EXHIBIT II-11

MODIFIED ACTUAL DIRECT MATERIAL COSTS

(MODIFIED FOR DESIGN CHANGES)

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	-
03	Building Ways and Launching	-
05	Mold Loft	-
06	Warehousing	-
07	Construction Services	-
08	Clean Up	-
09	Testing and Inspection	-
11	Insurance, Christening, etc.	-
Sub-total	Preliminary Items	-
01	Engineering	-
02	Planning and Production Control	-
85	Supervision	-
Sub-total	Staff Items	-
13	Hull Bottom	.0173
15	Hull Bulkheads and Framing	.0863
17	Hull Sides and Attachments	.0377
21	Hull Decks and Flats	.0268
23	Hull Inner Bottom	.0507
27	Bulworks and Windbreaks	.0008
37	Deckhouses	.0165
87	Steel Scrap	-
89	Welding Supplies	.0198
Sub-total	Hull Steel Items	.2558
19	Miscellaneous Hull Structure	.0007
25	Foundations and Tanks	.0095
33	Deck Fittings	.0011
35	Ladders below Deck	.0030
55	Ladders above Deck	.0032
73	Doors and Hatches	.0713
75	Benches and Shelving	.0008
77	Awnings	.0001
Sub-total	Minor Steel Items	.0896
29	Sternframe and Sterntube	.0143
31	Rudder	.0131
45	Port Lights and Windows	.0018
57	Derricks and Cranes	.0335
61	Steering Systems	.0054
63	Propellers and Shafting	.0212
65	Machinery and Equipment	.3029
69	Mooring Equipment	.0283
71	Safety Requirements	.0127
Sub-total	Machinery Items	.4330
39	Quarters Outfit	.0469
67	Heating, Ventilation & Air Conditioning	.0147
79	Electrical Systems	.0637
81	Blasting and Painting	.0220
83	Piping Systems	.0743
Sub-total	Outfitting Items	.2216
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	-
Sub-total	All Steel Items	.3454
Sub-total	All Outfitting Items	.6546
TOTAL	All Items	1.0000

Adjustments for Sub-Contract Practices (Step E)

Sub-contract practices differ greatly between the two shipyards.

IHI sub-contracts most of the steel fittings in each ship - foundations, ladders, masts, etc. - and much of the minor outfitting work, particularly that not covered by the pre-outfitting and modular outfitting work. This practice is directly related to IHI's employment practice: in a shipyard with a constant labor force in each shop, it becomes essential to sub-contract not only those activities that are only occasionally required but also a proportion of all activities, as an aid to workforce levelling. IHI is obviously quite capable of making and installing its own ladders but it chooses not to. IHI controls all sub-contractors, however, in away unfamiliar to U.S. shipyards, by supplying much of the material, closely supervising the work and tightly scheduling delivery and installation. Sub-contracts are based on a specified number of manhours and a labor rate, so that in effect, IHI is often only buying sub-contract labor.

LSCo sub-contracts those activities that are only occasionally required, preferring to do as much work as possible with the LSCo workforce and levelling the labor force as much as possible with the aid of ship repair and non-marine contracts.

IHI identified for this study the items that were sub-contracted by their Aioi yard on the first Future-32 and these are tabulated here in Exhibit 11-12. For each item, IHI calculated the adjustment to their actual costs necessary to make the scope of each item correspond to the scope of work as undertaken in LSCo. These adjustments, which necessarily involve a decrease immaterial dollars and a corresponding increase in manhours, in some cases cover manufacture and installation and in other cases only installation, depending on whether LSCo buys the item or whether they also make it. The adjustments include the modifications necessary for design changes.

LSCo normally sub-contracts flooring, insulation, air conditioning, ventilation, and refrigeration, all of which IHI does itself, except for some items, such as ducting, which it sub-contracts in the way described above. LSCo also sub-contracted extensive preliminary design and engineering work on this particular contract. The baseline estimate for the first LSCo bulker also includes a proposed sub-contract for quarters joinerwork: this is also converted here to direct labor manhours. LSCo has estimated the adjustments to their baseline estimate necessary to express these sub-contracts as direct material and labor, as shown in Exhibit II-13.

A.01

EXHIBIT II-12

ADJUSTMENTS FOR SUB-CONTRACT PRACTICES AT IHI

LSCO ITEM #	SUB-CONTRACT	REDUCTION IN MATERIAL PROPROTION	INCREASE IN LABOR PROPORTION
25	Foundations for Mooring Equipment	.00015	.00225
	Foundations for Life Saving Equipment	.00002	.00034
	Foundations for Auxiliary Machinery	.00061	.00373
	Tanks	.00411	.02204
		.00490	.02836
33	Bollards	.00022	.00119
		.00022	.00119
35	Gratings, Ladders, etc.	.00023	.00245
	Ladders, Walkways	.00038	.00183
	Gratings	.00054	.00388
	Ladders	.00017	.00122
		.00132	.00937
39	Joinerwork (raw materials)	.00153	.00741
	Joinerwork (accessories)	.00016	.00428
	Cabin Fittings	.00342	.01159
	Furniture	.00242	.00960
	Tiling	.00022	.00212
		.00776	.03501
55	Companion Ladder	.00016	.00094
	Walkways	.00010	.00048
	Hand Rails	.00038	.00163
	Staircases	.00033	.00186
	Banisters	.00021	.00105
		.00118	.00597
57	Mast	.00017	.00128
	Radar Mast	.00019	.00226
	Jib Rest	.00009	.00047
	Davit	.00009	.00048
	Suez Davit	.00008	.00042
		.00061	.00491
65	Hoist	.00223	.01056
		.00223	.01056
67	Ventilation Heads (quarters)	.00022	.00154
	Ducting (quarters)	.00029	.00116
	Ventilation Heads (holds)	.00017	.00151
	Ventilation Heads (other)	.00012	.00065
	Ducting (other)	.00006	.00020
	Air Duct	.00078	.00377
		.00163	.00884
71	Boat Davit	.00089	.00455
	Accommodation Ladder	.00048	.00433
	Pilot Ladder	.00014	.00061
		.00151	.00949
73	Doors & Manholes	.00132	.00554
	Hold Hatches	.00015	.00055
	Other Hatches	.00005	.00025
		.00153	.00634
75	Shelf	.00001	.00003
	Work Table	.00011	.00036
	Liner	.00033	.00153
		.00045	.00192
79	Cable Hangers	.00037	.00251
	Coaming	.00005	.00010
	Penetrating Piece	.00008	.00058
	Cable Pipe	.00018	.00037
	Foundations	.00033	.00298
		.00100	.00654
83	Spindle	.00034	.00031
	Pipe Hanger	.00019	.00490
	Pipe Cover	.00095	.00517
	Expansion Tank	.00014	.00075
	ME Exhaust Pipe	.00028	.00182
	Pipe Hangers	.00062	.00270
		.00252	.01564
	Total Adjustments	.02688	.14414

EXHIBIT II-13

ADJUSTMENTS FOR SUB-CONTRACT PRACTICES AT LSCO

LSCO ITEM #	SUB-CONTRACT	REDUCTION IN MATERIAL PROPORTION	INCREASE IN LABOR PROPORTION
01-01	Preliminary design	.08690	-
39-All	Joinerwork	.02720	.02622
39-50	Reefer spaces	.00021	.00025
39-90	Deck coverings	.00440	.00434
67-01	ER ducting, etc.	.00159	.00158
67-02	A/C and refrigeration equipment	.00728	.00720
67-03	Accom. ducting, etc.	.00093	.00092
83-49	Piping insulation	.00329	.00489
		.13181	.04538

2.4 Adjustments for Indirect Accounting (Steps F and G)

IHI identified for this study a number of costs which are classified in their system as indirect (whether overhead or G & A in nature) but which were identifiable as attributable to the baseline ship. These costs are tabulated in Exhibit 11-14.

In addition to these costs, LSCo estimated some IHI costs which in IHI's system are indirect but in LSCo are direct, based on examination of IHI's organization and manning. These costs are tabulated in Exhibit II-15.

In order to achieve direct comparability between the two sets of costs, those costs which in LSCo are direct but which in IHI are not only indirect but also unidentifiable or inestimable were removed from the LSCo estimated cost summary. These costs are tabulated in Exhibit II-16.

EXHIBIT II-14

INDIRECT COSTS IDENTIFIED AS ATTRIBUTABLE TO IHI HULL 2851

LSCO ITEM #	DESCRIPTION	LABOR PROPORTION	MATERIAL PROPORTION
00-01	Towing		.0056
00-02	Spare Parts		.0169
00-05	Commissions		.0813
			.1040
01-01	Engineering	.1915	
01-02	Model		.0018
01-03	Classification		.0079
		.1915	.0097
03-03	Launching		.0022
03-04	Drydocking		.0045
03-05	Moving of Vessel		.0010
			.0077
09-10	Sea Trials		.0011
			.0011
11-01	Insurance		.0052
			.0052
	Total Additional Costs:	.1915	.1277

EXHIBIT II-15

ADDITIONAL INDIRECT COSTS ESTIMATED BE AITRIBUTABLE TO IHI HULL 2581

LSCO ITEM #	DESCRIPTION	LABOR PROPORTION	MATERIAL PROPORTION
08	Cleaning (2 1/2%)	.0231	
		.0231	
85	Supervision (foremen 4.0%)	.0369	
	(shop managers 0.6:)	.0055	
	(dept. managers 0.1:)	.0009	
	Total Additional Costs:	.0665	

EXHIBIT II-16

DIRECT COSTS REMOVED FROM LSCO COST ESTIMATE

LSCO ITEM #	DESCRIPTION	REDUCTION IN LABOR PROPORTION	REDUCTION IN MATERIAL PROPORTION
00-01	Towing	.0004	
00-03	Customer Offices	.0003	.0003
	Building Ways	.0008	.0009
03:02	Cribbing	.0060	.0020
05	Hold Loft		.0028
06	Warehousing		.0026
07	Construction Services		.0064
08	Clean Up		.0006
09	Testing and Inspection	.0248	.0018
11-02	Photographs	.0001	
11-03	Christening	.0008	.0011
Total	All Items	.0332	.0190

2.5 Cost Comparison (Steps H and I)

The various re-arrangements, modifications and adjustments described above have finally resulted in two sets of comparable figures - direct labor manhours and direct material dollars - and a body of information that provides some grounds for comparison between LSCo'S and IHI's overhead and G & A rates.

In Step H, the two sets of direct labor manhours are compared and the ratios of IHI's actual figures to LSCo'S estimate are calculated: the results of this step are tabulated in Exhibit II-17. A similar comparison of direct material dollars results in the tabulation shown in Exhibit II-18.

The components of each shipyard's overhead and G & A are tabulated for comparative purposes in Exhibits II-19 and II-20.

Finally, in Step I, the ratios of IHI's actual results to LSCo's estimates are ranked in ascending order, as shown in Exhibits II-21 for labor and II-22 for material.

EXHIBIT II-17

COMPARISON OF ADJUSTED DIRECT LABOR MANHOURS

ITEM #	DESCRIPTION	RATIO	RANK
00	Contractual Costs	.4493	27
03	Building Ways and Launching	.3410	23
05	Mold Loft	.4956	29
06	Warehousing	1.4638	38
07	Construction Services	.5070	30
08	Clean Up	.1160	5
09	Testing and Inspection	.6768	33
11	Insurance, Christening, Etc.	-	
Sub-Total	Preliminary Items	.3634	
01	Engineering	.9902	36
02	Manning and Production Control	.2157	12
85	Supervision	.1081	4
Sub-Total	Staff Items	.3794	
13	Hull Bottom	.2842	14
15	Hull Bulkheads and Framing	.1752	8
17	Hull Sides and Attachments	.3777	24
21	Hull Decks and Flats	.4451	25
23	Hull Inner Bottom	.5319	31
27	Bulworks and Windbreaks	.1041	3
37	Deckhouses	.2847	15
87	Steel Scrap	-	
89	Welding Supplies	-	
Sub-Total	Hull Steel Items	.2549	
19	Miscellaneous Hull Structure	1.0394	37
25	Foundations and Tanks	.6909	34
33	Deck Fittings	.1372	6
35	Ladders below Deck	.3039	18
55	Ladders above Deck	.3169	21
73	Doors and Hatches	.1872	9
75	Benches and Shelving	.1463	7
Sub-Total	Minor Steel Items	.3266	
29	Sternframe and Sterntube	.0113	1
31	Rudder	.0575	2
45	Port Lights and Windows	.3090	19
57	Derricks and Cranes	.1940	11
61	Steering Systems	.3322	22
63	Propellers and Shafting	.2181	13
65	Machinery and Equipment	.2944	17
69	Mooring Equipment	.1903	10
71	Safety Requirements	.9723	35
Sub-Total	Machinery Items	.2259	
39	Quarters Outfit	.5818	32
67	Heating, Ventilation, Air Cond.	.3134	20
79	Electrical Systems	.2924	16
81	Blasting and Painting	.4473	26
83	Piping Systems	.4623	28
Sub-Total	Outfitting Items	.4321	
Total	All Items	.3249	
Sub-Total	Preliminary and Staff Items	.3729	
Sub-Total	All Steel Items	.2656	
Sub-Total	All Outfitting Items	.3817	
Total	All Items	.3249	

EXHIBIT II-18

COMPARISON OF ADJUSTED DIRECT MATERIAL DOLLARS

ITEM #	DESCRIPTION	RATIO	RANK
00	Contractual Costs	1.6510	31
03	Building Ways and Launching	1.0534	30
05	Mold Loft	-	
06	Warehousing	-	
07	Construction Services	-	
08	Clean Up	-	
09	Testing and Inspection	.6689	16
11	Insurance, Christening, etc.	.0786	1
Sub-Total	Preliminary Items	.8555	
01	Engineering	.7499	20
02	Planning and Production Control	-	
85	Supervision	-	
Sub-Total	Staff Items	.7499	
13	Hull Bottom	.7945	25
15	Hull Bulkheads and Framing	.7942	23
17	Hull Sides and Attachments	.7823	22
21	Hull Decks and Flats	.7466	19
23	Hull Inner Bottom	.7944	24
27	Bulwarks and Windbreaks	.8673	26
37	Deckhouses	.5438	10
87	Steel Scrap	-	
89	Welding Supplies	.6956	17
Sub-Total	Hull Steel Items	.7198	
19	Miscellaneous Hull Structure	1.8076	33
25	Foundations and Tanks	2.6918	34
33	Deck Fittings	.1270	2
35	Ladders below Deck	.5447	11
55	Ladders above Deck	.8772	27
73	Doors and Hatches	.6621	15
75	Benches and Shelving	.4091	5
77	Awnings	.5166	9
Sub-Total	Minor Steel Items	.6633	
29	Sternframe and Sterntube	1.6612	32
31	Rudder	3.3006	35
45	Portlights and Windows	.3167	3
57	Derricks and Cranes	.7241	18
61	Steering Systems	.4472	6
63	Propellers and Shafting	.8984	28
65	Machinery and Equipment	.6456	14
69	Mooring Equipment	.4692	7
71	Safety Requirements	.4067	4
Sub-Total	Machinery Items	.6568	
39	Quarters Outfit	.5758	12
67	Heating, Ventilation and Air Cond.	.9690	29
79	Electrical Systems	.4739	8
81	Blasting and Painting	.5783	13
83	Piping Systems	.7584	21
Sub-Total	Outfitting Items	.6023	
Total	All Items	.6778	
Sub-Total	Preliminary and Staff Items	.8464	
Sub-Total	All Steel Items	.7055	
Sub-Total	All Outfitting Items	.6379	
Total	All Items	.6778	

EXHIBIT II-19

COMPARISON OF OVERHEAD COST CATEGORIES

LSCo		IHI	
60xx	Indirect labor, including superintendents, guards, janitors, clerical support, warehousing, purchasing, estimating, program management and direct personnel charging indirectly.	13xx	Sub-contractor support
		14xx	Costs of chartering tugs and cranes and of blasting and priming steel at mill
		15xx	Operating supplies
		16xx	Fuel and gas
		21xx	Safety supplies
		22xx	Small tools
61xx	Indirect expenses, including dues and subscriptions, travel and entertainment, employee relations employee training, safety program,	23xx	Routine maintenance and repair
		24xx	" " " "
		25xx	" " " "
62xx	Maintenance and repair	31xx	Office supplies and copying
63xx	" " "	33xx	Domestic travel
64xx	" " "	34xx	Printing
65xx	Other overhead accounts, including social security taxes, unemployment taxes, depreciation, engineering supplies, vacations, holidays, group insurance.	35xx	Cleaning
		36xx	Welding tests
		37xx	Training
		41xx	Entertainment - major
		42xx	" - minor
		43xx	Books and newspapers
		44xx	Overseas travel
		45xx	Communications
		46xx	Dues
		47xx	Overseas offices
		48xx	Advertising
		49xx	Safety equipment, health, recreation, employee welfare
66xx	Safety supplies.	50xx	Employee costs
67xx	Operating supplies	51xx	Electricity
68xx	Other overhead accounts, including workers' compensation insurance general insurance, gases, utilities.	52xx	Water
		53xx	Data processing
		54xx	Miscellaneous, including accommodation, shipyard hotel, boiler testing and inspection, crane testing and inspection, fishermen's compensation, cleaning of uniforms, license fees.
69xx	Other overhead accounts, including small tools, rentals profit sharing plan, pension plan, Government compliance, first aid, physical examinations, inventory variations, janitorial services, shop supplies, materials handling, sand removal.	57xx	In-yard transportation
		58xx	Estimating
		59xx	Tugboats
		61xx	Indirect labor
		62xx	" "
		63xx	" "
		64	Rentals
		65	Insurance
		66	Property taxes
		67	Depreciation
		68	Major maintenance and repair

EXHIBIT II-20

COMPARISON OF G & A COST CATEGORIES

	LSCo	IHI
80xx	Salaries of management, industrial relations, accounting and data processing personnel	The costs carried either by a district office or by the head office - include those of:
82xx	G & A expenses, including dues and subscriptions, public relations, travel and entertainment, relocation, legal arid professional services.	Industrial relations Personnel Finance and accounting Purchasing Computerization Marketing and sales Corporate planning and control Inspection General administration Contract administration General management Research and development Design and engineering
83xx	Other G & Accounts, including telephones, telegraph, Social Security taxes, depreciation, conventions, advertising, donations, postage, insurance, rentals, profit sharing, vacations, thrift plan,	

EXHIBIT II-21

RANKING OF COMPARATIVE DIRECT LABOR RATIOS

RANK	ITEM #	DESCRIPTION	
1	29	Sternframe and Sterntube	.0113
2	31		.0575
3	27	Bulworks and Windbreaks	.1041
4	85	Supervision	.1081
5	08	Clean Up	.1160
6	33	Deck Fittings	.1372
7	75	Benches and Shelving	.1463
8	15	Hull Bulkheads and Framing	.1752
9	73	Doors and Hatches	.1872
10	69	Hooring Equipment	.1903
11	57	Derricks and Cranes	.1940
12	02	Planning and Production Control	.2157
13	63	Propellers and Shafting	.2181
14	13	Hull Bottom	.2842
15	37	Deckhouses	.2847
16	79	Electrical Systems	.2924
17	65	Machinery and Equipment	.2944
18	35	Ladders below Deck	.3039
19	45	Port Lights and Windows	.3090
20	67	Heating, Ventilation, Air Cond.	.3134
21	55	Ladders above Deck	.3169
22	61	Steering Systems	.3322
23	03	Building Ways and Launching	.3410
24	17	Hull Sides and Attachments	.3777
25	21	Hull Decks and Flats	.4451
26	81	Blasting and Painting	.4473
27	00	Contractual Costs	.4493
28	83	Piping Systems	.4623
29	05	Mold Loft	.4956
30	07	Construction Services	.5070
31	23	Hull Inner Bottom	.5319
32	39	Quarters Outfit	.5818
33	09	Testing and Inspection	.6768
34	25	Foundations and Tanks	.6909
35	71	Safety Requirements	.9723
36	01	Engineering	.9902
37	19	Miscellaneous Hull Structure	1.0394
38	06	Warehousing	1.4638

EXHIBIT II-22

RANKING OF COMPARATIVE DIRECT MATERIAL RATIOS

RANK	ITEM #	DESCRIPTION	RATIO
1	11	Insurance, Christening, etc.	.0786
2	33	Deck Fittings	.1270
3	45	Portlights and Windows	.3167
4	71	Safety Requirements	.4067
5	75	Benches and Shelving	.4091
6	61	Steering Systems	.4472
7	69	Mooring Equipment	.4692
8	79	Electrical Systems	.4739
9	77	Awnings	.5166
10	37	Deckhouses	.5438
11	35	Ladders below Deck	.5447
12	39	Quarters Outfit	.5758
13	81	Blasting and Painting	.5783
14	65	Machinery and Equipment	.6456
15	73	Doors and Hatches	.6621
16	09	Testing and Inspection	.6689
17	89	Welding Supplies	.6956
18	57	Derricks and Cranes	.7241
19	21	Hull Decks and Flats	.7466
20	01	Engineering	.7499
21	83	Piping Systems	.7584
22	17	Hull Sides and Attachments	.7823
23	15	Hull Bulkheads and Framing	.7942
24	23	Hull Inner Bottom	.7944
25	13	Hull Bottom	.7945
26	27	Bulwarks and Windbreaks	.8673
27	55	Ladders above Deck	.8772
28	63	Propellers and Shafting	.8984
29	67	Heating, Ventilation and Air Cond.	.9690
30	03	Building Ways and Launching	1.0534
31	00	Contractual Costs	1.6510
32	29	Sternframe and Sterntube	1.6612
33	19	Miscellaneous Hull Structure	1.8076
34	25	Foundations and Tanks	2.6918
35	31	Rudder	3.3006
	87	Steel Scrap	

26 Analysis of Variances (Step J)

26.1 Labor

The most significant result of the comparison shown in Exhibits II-17 and II-21 was that LSCo's cost was expected to be lower than IHI's in only two out of 38 items, both of these being of minimal significance. If the significant items are defined as those with the largest number of manhours, the single *most* important is clearly Item 15, Bulkheads and Framing, which shows a ratio of .1752, eighth in the ranking. Of the six groups of items, the two lowest ratios are Machinery at .2259 and Hull Steel at .2549. The major outfitting items have the best ratio, .4321 as a group.

The conclusion was obvious. There was no single area of shipbuilding activity in which IHI was not expected to perform significantly better than LSCo and all activities therefore needed to be studied in the course of the Technology Transfer Program.

26.2 Material

As in the labor comparison, IHI's material costs were found to be significantly lower than LSCo's estimated costs in all but-a small number of relatively insignificant items. The overall difference, however, was much less than that between the respective labor costs. In the *most* significant item, Machinery, the ratio was .6456, close to the overall average of .6778. Hull Steel was as much as .7198, the greater variances being in outfitting material.

2.6.3 Overhead and G & A

A detailed comparison of indirect costs was not an integral part of the cost analysis task but is of general interest in the context of comparison of overall costs. After all the adjustments for comparability of accounting described earlier: IHI's overhead costs were about 23% and their G and A costs about 79% of LSCOs.

SECTION 3

REVIEW OF COST ACCOUNTING SYSTEMS (STEP K)

The procedures used for planning, recording and controlling expenditures on new construction programs in the two shipyards are essentially the same in principle but are handled in quite substantially different ways. In this part of this report these procedures are briefly described and compared and some conclusions are drawn as to areas in which Livingston and other U.S. shipyards could learn from IHI.

The basic procedure is common to both shipyards. It is illustrated here in the flow chart of Exhibit III-i. The different ways in which this procedure is implemented are described below.

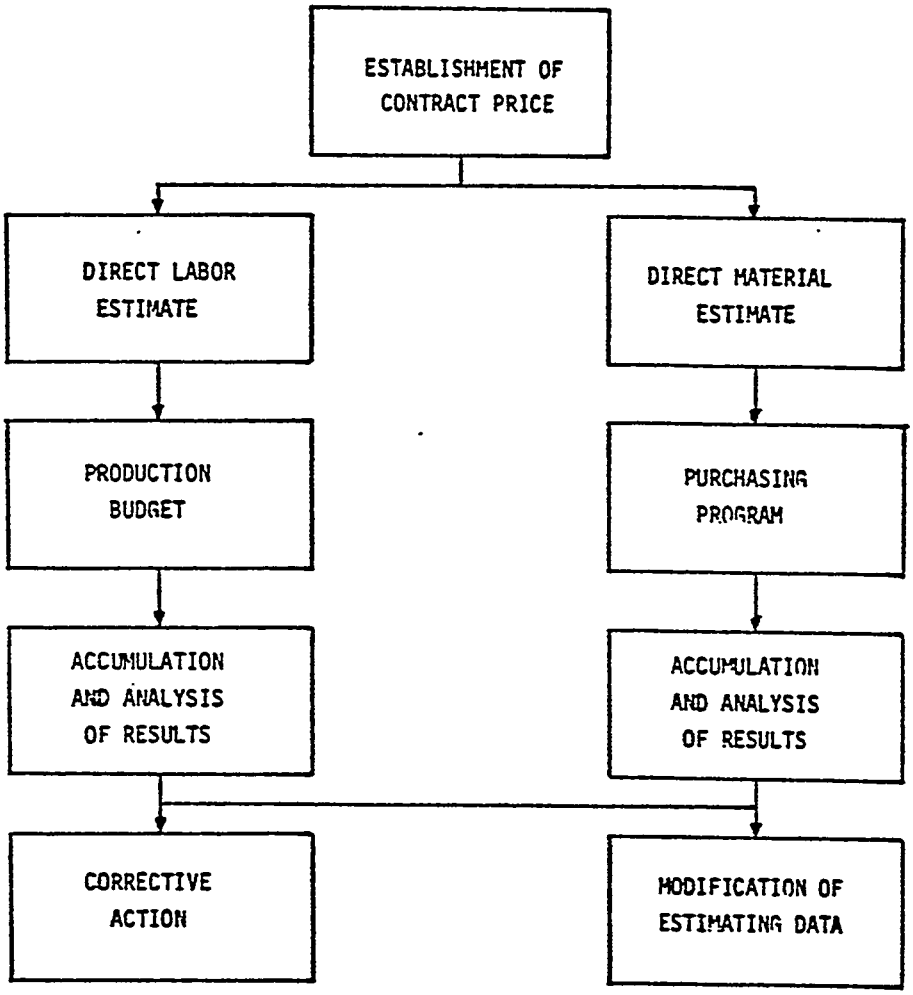
3.1 Livingston's Cost Accounting Procedures

3.1.1 Program Budgeting at Livingston

The estimating process in ship construction is based on the application of unit costs of labor and material to a material take-off and is dependent for its accuracy firstly on the accuracy and degree of detail of the material take-off and secondly on the reliability of the unit costs of labor (manhours per ton, etc.) and material applied to that take-off. The accuracy and degree of detail of the material take-off are dependent on the amount of available design information, on the time available for estimating and on the level of priority assigned by management to the estimating effort. The reliability of the unit labor cost data depends on the familiarity of the shipyard with the ship type. The reliability of the unit material cost data depends on the familiarity of the shipyard with the ship type, on the time available for obtaining current material prices and on the level of priority assigned to the effort. Familiarity, in this context, means not only experience with the ship type but also recent experience, since estimating data, whether labor or material, become less reliable with age.

EXHIBIT III-1

BASIC PROJECT COST ACCOUNTING PROCEDURE



Livingston's Estimating department prepares a preliminary SALES ESTIMATE using the techniques described above, in which the estimated direct costs are extended to a sales value according to the following formula:

$$SE=[DL\ (1 + OH) +DM] X\ (1 +GA)X(l+P)$$

where: SE = sales estimate

DL = estimated direct labor cost

OH = overhead rate

DM = estimated direct material cost

GA= general and administrative expense rate

P = profit factor

In this calculation, DL and DM must be estimated in the values at which they will be incurred; i.e., fully escalated, unless there is a separate contractual provision for escalation. Accordingly, the Estimating department is provided with an outline schedule of projected expenditures for both labor and material costs, usually in S-curve form, by the Central Planning and Control department, which allows them to calculate escalated values of labor and material costs based both on known factors such as the shipyard's labor contract and on assumptions regarding inflation.

At any given time, the values of OH, GA and P are set by management on the basis of past experience and future expectations.

In the bid review process, management may modify any of the five variables in the sales estimate function on the basis of their expectations or intentions. The final sales estimate may therefore vary substantially from the preliminary sales estimate. Similarly, in the course of the contract negotiation, management may further modify the structure of the sales estimate, so that the CONTRACT PRICE may vary substantially from both the preliminary and the final

sales estimate.

Following the establishment of a contract price, the Estimating department modifies its direct labor and material estimates to the extent that this is necessary in order that their combined sales value, after extension by the final agreed values of OH, G4 and P, should match the contract price. The Estimating department then turns the direct labor estimate over to the Central Planning and Control department and the direct material estimate to the Material department.

3.1.2 Labor Cost Budgeting and Control at Livingston

The direct labor estimate is in the form of manhours for each item and subitem of the Livingston new construction item classification. The Central Planning and Control department distributes the manhours by item and subitem to each shipyard department. This level of detail is called the PRODUCTION BUDGET and after approval by the Program Manager is issued to the Programs Planning section of the Production Planning and Control department.

The Programs Planning section breaks the production budget down to progressively more detailed levels, based on past records of actual requirements, difficulty factors and similar parameters:

first, into the zones into which the ship is divided; e.g.,

Zone 1: mid-body
Zone 2: stern portion
Zone 3: bow portion
Zone 4: superstructure
Zone 5: external items
Zone 0: support activities

•second, into work groups, which for steelwork are the erection units and for outfitting and other activities are either the erection modules or are the same as the new construction item numbers.

• third, into work orders, which are generally numbered the same as both process codes and gate numbers, a “gate” being a process lane, a physical area or group of work stations where a particular process is carried out.

This breakdown is placed in a computer file and can be reviewed in the form of a detailed listing with sub-totals at the different levels.

This budget is issued to the production departments in the form of work orders. While a production supervisor (or foreman) requires a number of different documents before he can undertake a piece of work - various schedules, material lists, engineering drawings and sketches - the work order is the controlling document since without it he has no authority to act. Indeed, if he does the work without it, the labor charges involved will be rejected the next day by the labor cost computer system. This system ties the work covered by each work order to a single foreman. Hours charged to each work order number can only be charged after the work order has been “opened” and before it is “closed” by the Production Planning and Control department; they can *only* be charged by personnel of the departments identified on the work order; and the charges must be approved by the responsible foreman. Exceptions are listed daily and rectified within 24 hours. The average size of work order is about 400 manhours and the average duration about 14 days. The average number of rejected charges is about 150 per day, not counting rejections of a different nature, such as arise from what are known as payroll errors - mistakes involving the number of hours worked or the rate to be paid. This error rate averages 10% of the total numberof charge cards and works out to about one per foreman.

The labor cost computer system sumarizes labor cost in manhours in 26 different reports, some daily, some weekly, some semi-monthly, and some monthly. These reports are described briefly in Exhibit III-2. In addition, a simple procedure is available to Livingston management by which, on request, specific abstractions of labor cost detail can be obtained at almost any level of detail. As can be seen from Exhibit III-2, the number and scope of reports available is so substantial that no one individual could conceivably review them all and the sheer weight of paper involved is daunting. Accordingly, several of these reports are only run when requested and several of the more detailed (and heavier) are not printed but converted to microfiche directly from magnetic tape.

The Central Planning and Control department analyzes the semi-monthly labor cost reports and maintains plots and other tabulations of productivity and performance, by program, by department, by process and by item/subitem (in the new construction item classification). These data are used both for management control purposes and to revise the Estimating department's date files.

Projections of final labor manhours are performed arithmetically in the course of generating several labor cost reports. The basic projection calculation is performed on each work order individually, according to the following (simplified) principles:

Closed Work Orders: the actual recorded manhours are, of course, the final manhours.

Open Work Orders: the actual recorded manhours to date are divided by the actual percentage progress to date (as estimated by the Production Planning and Control department planner who generated the work order).

EXHIBIT III-2

LSCO LABOR COST CONTROL REPORTS

REPORT #	REPORT TITLE	FREQUENCY
110	Combined Labor Files	Bi-weekly
145	Issued WO Analysis	"
150.01	Item/Subitem Report by Zone & Job	"
150.02	Item/Subitem Report by Job	"
155	Severe Variances on Issued WOs	"
160	Issued WO Analysis by Gate	"
165	Manhour Report by Cost Category	Semi-monthly
170.01	WO Process Cost Report by Zone (Direct Labor Only)	"
170.02	WO Process Cost Report by Zone (All Labor)	"
180	New Construction Re-work Listing	"
300	WO Maintenance Exception List	Daily
330	WO Maintenance Activity Report	"
335.01	WO Master Listing	"
335.02	WO Master Listing - Active WOs Only	"
520	Physical Progress Reporting Document	Semi-monthly
530	WO Log	Semi-weekly
535	WO Log by Item	"
540	Schedule of WOs to be issued	Bi-weekly
550	WO Change Report	"
600	MO Reference Cards	Daily
660	MO Master Listing - Active WOs Only	On Request
662	Open WOs Showing 100% Progress	Semi-monthly
667	WO Master Listing - Active WOs by Foreman	On Request

Unopened Work Orders: the budgeted manhours are assumed to be the final manhours.

The labor cost system, being linked to the payroll system, also calculates actual labor costs in dollars. Projections of final labor costs are made by hand on the basis of current average rates, the provisions of the company's labor agreements and the planned distribution of labor manhour expenditure against time, as developed by the Central Planning and Control department.

3.1.3 Material Cost Budgeting and Control at Livingston

The direct material estimate is in the form of dollars for each item and subitem of the Livingston new construction item classification.

Purchase requisitions are written by the Material section of the Engineering department, using the official ship specification as one source document and completed engineering drawings as the other. Purchase requisitions are simultaneously entered in a computer file by means of a remote terminal. Purchase requisitions, suitably approved by both the Project Engineer and the Program Manager, are sent to the Purchasing department and routed to an individual buyer according to the item-subitem number of the material being purchased.

The buyer purchases the material listed on each requisition in the usual way and issues a purchase order, the details of which are also added to the material computer file, by means of a second remote terminal. Invoiced costs are compared manually to the material estimate.

Projections of final material dollar cost are performed manually by item and subitem by the addition of total cost to date and each buyer's tabulation of the estimated cost still to be incurred.

3.1.4 Indirect Cost Budgeting and Control at Livingston

Indirect costs are budgeted and controlled at Livingston by department and by cost account, independently of individual new construction programs. Budgets are established on the basis of corporate planning for manning levels and for the split of work between new construction (commercial ships), new construction (offshore vessels), marine repair and other activities. They are controlled by means of monthly review of individual departments' performance followed by corrective action as required.

New construction programs are charged with indirect costs on the same basis as they were contracted. If a ship's contract price includes an overhead rate of 90%, that program is charged for overhead at 90% of direct labor costs, whether the division's actual overhead is running at 85% or 95%. Any overhead cost that is either over- or under-accrued as a result of this approach is credited or debited only in month-end financial results for the shipyard as a whole. It is, of course, possible for one program to be over-accruing overhead at the same time as another is under-accruing. This is, however, irrelevant to the shipyard's performance on an individual program, which is primarily dependent on its direct costs.

3.1.5 Program Control at Livingston

Based on the various budgets and reports described briefly above, Livingston's Central Planning and Control department produces two program summaries for each new construction program. The first, the monthly Percentage Completion Report summarizes performance to date in dollar terms at each level of detail of the contract price - direct labor, direct material, overhead, g and a and profit. The second, the hi-monthly Contract Status Report, summarizes expected performance at completion, based on the current labor and

material cost projections. These reports also show the impact on each program's results of over- or under- absorption of overhead and G and A.

● 3.2 IHI's Cost Accounting Procedures

3.2.1 Program Budgeting at IHI

Marketing, estimating and contract negotiation are handled by IHI's head office on behalf of all IHI's six shipyards and other industrial plants.

For each new ship, the Operations Control department at head office prepares an INNER SALES PRICE which is essentially the budget to which the ship is to be built, regardless of contract price. This is then split between IHI divisions, with each portion being known as the SHARED SALES PRICE. The shipyard's shared sales price includes only those costs to be incurred by the shipyard, excluding work to be done by other divisions, such as main engine construction, and major material acquisition, which is done centrally at head office, in order to obtain the maximum benefits of ordering in quantity. The Operations Control department also prepares a major-events schedule to which the shipyard will work.

The shared sales price, broken down according to the following formula, is turned over to the shipyard's Production Control department for development of the next level of planning. The Production Control department is the shipyard General Superintendent's staff and is roughly analogous to Livingston's Central Planning and Control department.

$$SSP=[DL\ (LR+OH)+DM+DE]X\ (l+\ GA)\ X\ (l+P)$$

where SSP = shared sales price

DL = estimated direct labor manhours

LR = current average direct labor rate for this shipyard in ¥ per manhour

OH = current average cost of overhead for this shipyard calculated as the ratio of total indirect costs to total direct labor manhours

DM = estimated cost of direct materials to be bought by the shipyard

DE = estimated cost of direct expenses to be incurred by the shipyard

GA= current corporate general and administrative expense rate, set by head office

P = profit factor, set by head office.

3.2.2 Labor Cost Budgeting and Control at IHI

The Production Control department incorporates the details of the shared sales price into its departmental budgeting system. For each department (hull, fitting, repair and general) a departmental budget control sheet is maintained, covering a six-month period and specifying all direct and indirect manhours and costs, budgeted, targeted (usually at 95% of budget) and actual, month by month. As each month's actual results are added a fresh projection of the six-month period's results is made. The sales price for a new ship will not normally need to be added to the current control sheet but must be incorporated in subsequent editions.

The Production Control department also prepares Departmental Budget Target Sheets for each indirect cost account on each of which a specific proposal for reducing indirect cost is described, a target budget established and actual results recorded over the six-month period. Indirect costs are measured in yen per direct manhour.

A third basic budgeting document is the Departmental Execution Plan, in which each department's planned and actual performance over the six-month period are tabulated and plotted for a number of parameters, including direct labor manhours, subcontractor manhours, manpower, attendance and others.

Finally, the Production Control department also maintains an Operating Manpower Plan which spells out manpower requirements monthly for two years, compares them to projected manpower availability and describes its proposals for accommodating any differences.

At the next level of planning, the Production Planning sections of the Hull and Fitting Departments are each supplied by the production Control department with a total number of available direct manhours and an -S-curve showing their planned expenditure against time.

The Hull department's production Planning section then performs a similar process, splitting its manhour budget between shops:

- fabrication
- assembly
- erection
- transportation

and developing S-curves for each. The Fitting department's Production Planning section does the same for:

- painting
- deck fitting
- quarters fitting
- module fitting
- specialized fitting
- electrical

A meeting is then held to review these budgets and outline schedules. The shipyard's General Superintendent can reassign manhours between shops and between the Hull and Fitting departments. He can go back to the head office for more manhours if the total budget is considered insufficient, though this is apparently rare. He can also hold a portion of the man-hour budget in reserve if he or his staff feel that the budget is more than enough or if he wants to "target" a department.

Following this meeting, the budgets and schedules are then passed down to the staff of each of the ten shops, who schedule the work to be done and the manpower assignments according to the procedures described in the Shipbuilding Technology Transfer Program's Report on Planning and Production Control (LSCo. 2123-3.0-4-1).

Actual direct labor costs are returned to the planners at each level in the same detail as that in which their expenditure was scheduled, that is, by department, by shop, by foreman and by assistant foreman: because this breakdown is analogous with the different ship construction processes it provides enough detail to allow manual calculation and plotting of productivity and performance parameters. Each level of planning is-interested only in the results at that level. Thus the shop planners require the fullest detail, but for their own shop only; the departmental planners only require total shop results, for their department only; the Production Control department requires only the total results of the two new construction department, Hull and Fitting, for incorporation in its control sheets; and the Operations Control Department at head office is interested only in total contract results from each shipyard.

3.2.3 Material Cost Budgeting and Control at IHI

The bulk of the material required for each ship is purchased by the central Material department at IHI's head office. The shipyards themselves do not even have purchasing departments; the relatively low level of purchasing effort left to them is performed by regional Purchasing departments. At Aioi, for instance, the regional purchasing department serves four plants - the shipyard, the diesel engine works, the boiler works and the foundry.

With this arrangement, shipyard personnel have no need to worry about material cost budgeting and control since it is largely out of their hands.

3.2.4 Indirect Cost Budgeting and Control at IHI

The Production Control department's procedure for budgeting and controlling indirect costs has already been touched on in the description of the Departmental Budget Target Sheets for indirect cost accounts. The calculation of the indirect charge rate as the ratio of total indirect costs to total direct manhours has also already been mentioned.

The differences between IHI's and Livingston's definitions of "direct" and "indirect" were identified in detail in Section 2 of this report.

3.2.5 Program Control at IHI

The Production Control department prepares a monthly profit and loss statement for each program, subdivided by cost account and presented on a six-month spread-sheet. These program reports are based on the budgets issued by the Production Control department and on the actual costs returned: they contain no more detail than the department included in its level of the budgeting process.

The results of each program are incorporated in a monthly overall profit and loss statement for the shipyard as a whole, also prepared by the Production Control department and submitted to head office. Programs are included in this report only in the month in which they are completed, when they are reported in total. This technique is not as extraordinary as it sounds to a U.S. shipbuilder because of the high level of output of IHI's shipyards, the short construction times and the frequency of ship deliveries.

3.3 Comparison of IHI and Livingston Practice

There are two significant differences between Livingston and IHI practice. There is a reason for each and a conclusion to be drawn.

(1) The budgeting process at IHI is much more stratified than at Levingston. In IHI the process flows down through five hierarchical levels and back again:

Level	Detail
Operations Control	By shipyard and by ship
Production Control	By department
Program Planning	By shop
Shop Planning	By foreman and assistant foreman
Foreman	Daily refinement

In Livingston, in contrast, the first three levels are handled by the Central Planning and Control department and the last two by Production Planning and Control. There are specific reasons for this approach in each case. The IHI technique of planning at each level with the staff at that level is clearly desirable in that the staff at each level have the best understanding of both the capabilities and the limitations of the shipyard at that level. Each staff engineer/planner is an expert in his own area and at his own level of detail.

At Livingston, the planning function is in a long slow process of change, not only as IHI's techniques are introduced but also because of the parallel introduction of a number of controls (closing of loopholes) and computer systems that were needed and were in process of introduction before the arrival of IHI's advisory team. Accordingly, it is easier to manage these changes if the planners involved are not scattered throughout the organizational structure.

It is also relevant to remember that IHI's staff planners are mostly degreed engineers requiring very little direction and that IHI's personnel are all thoroughly familiar with the system. It is therefore quite practical to assign a single staff engineer to work with a single foreman, while in Livingston this will not be possible until (a) all systems are operating smoothly, (b) both foremen and planners are better educated, and (c) the planning and control function is able to justify a level of staffing that is more comparable to that at IHI.

(2) The feedback of actual cost data at IHI is only in as much detail as was the original budgetary data. At each level of the planning hierarchy, the planner only gets back as much detailed information as he generated in the first place. At Livingston, by contrast, most reports are in extensive detail. Extensive detail was called for deliberately, in an effort to ensure that actual results can be analyzed as thoroughly as possible and in the expectation that the passage of time would make it clear which reports were the most valuable. In this respect, therefore, the large number of reports and their great detail is not yet a cause for concern. It is, however, a valid criticism that Livingston has too few summary reports: so much effort went into developing a comprehensive system of detailed reports that the need for summary reports at different levels of detail was largely overlooked. This deficiency is now being corrected.

SECTION 4

ANALYSIS OF ACTUAL RESULTS

This report was written shortly before the conclusion of the Shipbuilding Technology Transfer Program, in March 1981. At that time, the first LSCo bulker was effectively complete apart from sea trials; the second ship was 68% complete and about two months away from launching; the third, ship was only 11% complete.

4.1 Measurement of Actual Costs (Step L)

Throughout the course of the Shipbuilding Technology Transfer Program, actual costs have been collected and compared to the original estimate.

projections of manhours at completion were made monthly after each vessel had reached 25% of manhour expenditure. Follow-ship projections were assumed to be the same as those for the preceding ship until the 25% mark was reached. As a result, the third-ship projection used in this report is essentially the same as that for the second ship, although some improvement may reasonably be expected.

Projections of material cost at completion were made bi-monthly. Almost all material was purchased in quantities of three, with the result that the few variances between the material cost projections for each ship arise either from specifically "front-end-load" items or from the effects of escalation clauses on certain major items. The first-ship material projection is not therefore a genuinely single-ship cost: although it includes all the front-end-load elements, it is under-stated to the extent that most of the items bought in bulk were bought on a three-ship basis. Insofar as these items are generally items for which no multiple-order discount is usually available, however, no dramatic loss of significance is involved. At the time of writing, virtually all material for all three ships had been

Purchased. The only variances between the three material cost projections and the final cost returns on each ship will arise either from variations between estimated and actual consumption of stock items during the remainder of the construction period or from changes in escalation requirements on items bought but not yet delivered.

Exhibits IV-1, IV-2 and IV-3 present the projected final manhours for each ship. Exhibit IV-4 presents the projected final material cost for the first ship: in the light of the foregoing discussion it is not relevant to include the follow-ship material cost projections.

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EXHIBIT IV-2

PROJECTED FINAL SECOND SHIP MANHOURS

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	.0008
03	Building Ways and Launching	.0142
05	Mold Loft	.0039
06	Warehousing	.0101
07	Construction Services	.0264
08	Clean Up	.0357
09	Testing and Inspection	.0341
11	Insurance, Christening, etc.	.0004
Sub-total	Preliminary Items	.1256
01	Engineering	.0093
02	Planning and Production Control	.0237
85	Supervision	.1071
Sub-total	Staff Items	.1402
13	Hull Bottom	.0229
15	Hull Bulkheads and Framing	.2046
17	Hull Sides and Attachments	.0872
21	Hull Decks and Flats	.0330
23	Hull Inner Bottom	.0635
27	Bulworks and Windbreaks	.0019
37	Deckhouses	.0428
87	Steel Scrap	-
89	Welding Supplies	.0004
Sub-total	Hull Steel Items	.4564
19	Miscellaneous Hull Structure	.0005
25	Foundations and Tanks	.0144
33	Deck Fittings	.0039
35	Ladders below Deck	.0093
55	Ladders above Deck	.0039
73	Doors and Hatches	.0117
75	Benches and Shelving	.0012
77	Awnings	-
Sub-total	Minor Steel Items	.0448
29	Sternframe and Sterntube	.0017
31	Rudder	.0054
45	Port Lights and Windows	.0004
57	Derricks and Cranes	.0046
61	Steering Systems	.0003
63	Propellers and Shafting	.0016
65	Machinery and Equipment	.0096
69	Mooring Equipment	.0031
71	Safety Requirements	.0010
Sub-total	Machinery Items	.0277
39	Quarters Outfit	.0221
67	Heating, Ventilation & Air Conditioning	.0038
79	Electrical Systems	.0342
81	Blasting and Painting	.0699
83	Piping Systems	.0753
Sub-total	Outfitting Items	.2054
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	.2658
Sub-total	All Steel Items	.5012
Sub-total	All Outfitting Items	.2331
TOTAL	All Items	1.0000

LSCO

EXHIBIT IV-3

PROJECTED FINAL THIRD SHIP MANHOURS

ITEM #	DESCRIPTION	PROJECTION
00	Contractual Costs	.0007
03	Building Ways and Launching	.0137
05	Hold Loft	.0337
06	Warehousing	.0097
07	Construction Services	.0251
08	Clean Up	.0361
09	Testing and Inspection	.0345
11	Insurance, Christening, etc.	.0004
Sub-total	Preliminery Items	.1239
01	Engineering	.0094
05	Planning and Production Control	.0226
85	Supervision	.1037
Sub-total	Staff Items	.1357
13	Hull Bottom	.0231
15	Hull Bulkheads and Framing	.2068
17	Hull Sides and Attachments	.0881
21	Hull Deck and Flats	.0333
23	Hull Inner Bottom	.0642
27	Bulworks and Windbreaks	.0020
37	Deckhouses	.0424
67	Steel Scrap	
89	Welding Supplies	.0004
Sub-total	Hull Steel Items	**.4603**
19	Miscellaneous Hull Structure	.0005
25	Foundation and Tanks	.0138
33	Deck Fittings	.0039
35	Ladders below Deck	.0094
55	Ladders above Deck	.0039
73	Doors and Hatches	.0118
75	Benches and Shelving	.0012
77	Awnings	
sub-total	Minor Steel Items	.0445
29	Sternframe and Sterntube	.0017
31	Rudder	.0055
45	Port Lights and Windows	.0004
57	Derricks and Cranes	.0046
61	Steering systems	.0004
63	Propellers and Shafting	.0016
65	Machinery and Equipment	.0097
69	Mooring Equipment	.0031
71	Safety Requirements	.0010
Sub-total	Machinery Items	.0280
39	Quarters Outfit	
67	Heating, Ventilation & Air Conditioning	**.0224**
79	Electrical Systems	**.0038**
81	Blesting and Painting	**.0345**
83	Piping Systems	**.0706**
Sub-total	Outfitting Items	**.0761**
		.2074
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	.2596
Sub-total	All Steel Items	.5048
Sub-total	All Outfitting Items	.2354
TOTAL	All Items	1.0000

LSCO

EXHIBIT IV-4

PROJECTED FINAL FIRST SHIP MATERIAL COSTS

ITEM #	DESCRIPTION	PROPORTION
00	Contractual Costs	.0239
03	Building Ways and Launching	.0138
05	Mold Loft	.0044
06	Warehousing	-
07	Construction Services	.0081
08	Clean Up	-
09	Testing and Inspection	.0063
11	Insurance, Christening, etc.	.0224
Sub-total	Preliminary Items	.0789
01	Engineering	.0739
02	Planning and Production Control	.0032
85	Supervision	-
Sub-total	Staff Items	.0771
13	Hull Bottom	.0135
15	Hull Bulkheads and Framing	.0606
17	Hull Sides and Attachments	.0300
21	Hull Decks and Flats	.0226
23	Hull Inner Bottom	.0312
27	Bulworks and Windbreaks	.0003
37	Deckhouses	.0203
87	Steel Scrap	-
89	Welding Supplies	.0126
Sub-total	Hull Steel Items	.1911
19	Miscellaneous Hull Structure	.0006
25	Foundations and Tanks	.0048
33	Deck Fittings	.0037
35	Ladders below Deck	.0038
55	Ladders above Deck	.0020
73	Doors and Hatches	.0644
75	Benches and Shelving	.0013
77	Awnings	.0001
Sub-total	Minor Steel Items	.0807
29	Sternframe and Sterntube	.0119
31	Rudder	.0080
45	Port Lights and Windows	.0014
57	Derricks and Cranes	.0052
61	Steering Systems	.0042
63	Propellers and Shafting	.0142
65	Machinery and Equipment	.2721
69	Mooring Equipment	.0272
71	Safety Requirements	.0113
Sub-total	Machinery Items	.3555
39	Quarters Outfit	.0426
67	Heating, Ventilation & Air Conditioning	.0189
79	Electrical Systems	.0467
81	Blasting and Painting	.0274
83	Piping Systems	.0812
Sub-total	Outfitting Items	.2168
Total	All Items	1.0000
Sub-total	Preliminary and Staff Items	.1560
Sub-total	All Steel Items	.2718
Sub-total	All Outfitting Items	.5723
TOTAL	All Items	1.0000

4.2 Comparison of First Ship Actual Costs (Step 11)

Exhibit IV-5 compares first-ship projected final manhours to the estimated manhours and Exhibit IV-6 compares them to IHI's first-ship manhours.

Exhibit IV-7 compares first-ship projected final material costs, adjusted for inflation, to the estimated material costs and Exhibit IV-8 compares them to IHI's first-ship material costs.

4.3 Analysis of Variances (Step N)

43.1 Labor

Only in the machinery group were actual manhours consistently below the estimated level: in the minor steel group there was some improvement and in the outfitting group the good performance on three items was more than cancelled out by the poor results on the other two. The worst over-runs were experienced on two support items, planning and production control and testing and inspection. The biggest impact, however, was in the 16% over-run on hull steel manhours. The comparison with IHI's actuals is inevitably even less favorable than was the earlier comparison of LSCo's estimate with IHI's actual manhours and there are no special lessons to be learnt.

43.2 Material

Material costs were generally in line with the estimate. It is difficult to draw conclusions from the apparent 4% over-run in the light of the very approximate way in which actual costs were de-escalated for comparative purposes: an increase in assumed annual inflation of about 1% would result in a one-to-one ratio. There are a few items which were significantly over-run but the only ones of any great absolute value were Piping Systems and Engineering. The two largest items, the Hull Steel group and Machinery and Equipment were close to the estimate. There is no particular new point to be made from the comparison with IHI's actual costs.

EXHIBIT IV-5

COMPARISON OF ACTUAL FIRST SHIP MANHOURS

(RATIO OF LSCO ACTUAL TO LSCO ESTIMATED MAHOURS)

ITEM #	DESCRIPTION	RATIO
00	Contractual Costs	.6667
03	Building Ways and Launching	1.6394
05	Mold Loft	1.2427
06	Warehousing	2.4043
07	Construction Services	1.4940
08	Clean Up	1.0255
09	Testing and Inspection	4.1424
11	Insurance, Christening, etc.	-
Sub-total	Preliminary Items	1.3709
01	Engineering	1.9704
02	Planning and Production Control	3.3224
85	Supervision	1.3919
Sub-total	Staff Items	1.7265
13	Hull Bottom	.9645
15	Hull Bulkheads and Framing	1.0136
17	Hull Sides and Attachments	1.8164
21	Hull Decks and Flats	1.6514
23	Hull Inner Bottom	1.0218
27	Bulworks and Windbreaks	.4772
37	Deckhouses	1.2131
87	Steel Scrap	-
89	Welding Supplies	-
Sub-total	Hull Steel Items	1.1647
19	Miscellaneous Hull Structure	1.3797
25	Foundations and Tanks	1.3392
33	Deck Fittings	1.0898
35	Ladders below Deck	.5718
55	Ladders above Deck	.6268
73	Doors and Hatches	.6503
75	Benches and Shelving	.2910
77	Awnings	-
Sub-total	Minor Steel Items	1.3258
29	Sternframe and Sterntube	.2601
31	Rudder	.7367
45	Port Lights and Windows	.2615
57	Derricks and Cranes	.3200
61	Steering Systems	.3000
63	Propellers and Shafting	.3418
65	Machinery and Equipment	.5420
69	Mooring Equipment	.8909
71	Safety Requirements	.5263
Sub-total	Machinery Items	.4789
39	Quarters Outfit	.8062
67	Heating, Ventilation & Air Conditioning	.3657
79	Electrical Systems	.9143
81	Blasting and Painting	1.5006
83	Piping Systems	1.6452
Sub-total	Outfitting Items	1.2364
Total	All Items	1.2116
Sub-total	Preliminary and Staff Items	1.5826
Sub-total	All Steel Items	1.1887
Sub-total	All Outfitting Items	1.0511
TOTAL	All Items	1.2116

EXHIBIT IV-6

COMPARISON OF ACTUAL FIRST SHIP MANHOURS

(RADIO OF IHI ACTUAL MANHOURS TO LSCO ACTUAL MANHOURS)

ITEM #	DESCRIPTION	RATIO
00	Contractual Costs	6.7400
03	Building Ways and Launching	.2080
05	Mold Loft	.3988
06	Warehousing	.6088
07	Construction Services	.3394
08	Clean Up	.1131
09	Testing and Inspection	.1635
11	Insurance, Christening, etc.	-
Sub-total	Preliminary Items	.2651
01	Engineering	.5075
02	Planning and Production Control	.0659
85	Supervision	.0777
Sub-total	Staff Items	.2198
13	Hull Bottom	.2946
15	Hull Bulkheads and Framing	.1728
17	Hull Sides and Attachments	.2080
21	Hull Decks and Flats	.2696
23	Hull Inner Bottom	.3260
27	Bulworks and Windbreaks	.2182
37	Deckhouses	.2347
87	Steel Scrap	-
89	Welding Supplies	-
Sub-total	Hull Steel Items	.2189
19	Miscellaneous Hull Structure	.7534
25	Foundations and Tanks	.5159
33	Deck Fittings	.1259
35	Ladders below Deck	.5315
55	Ladders above Deck	.5055
73	Doors and Hatches	.2879
75	Benches and Shelving	.5029
77	Awnings	-
Sub-total	Minor Steel Items	.4248
29	Sternframe and Sterntube	.0436
31	Rudder	.0781
45	Port Lights and Windows	1.1813
57	Derricks and Cranes	.6061
61	Steering Systems	1.1074
63	Propellers and Shafting	.6382
65	Machinery and Equipment	.5432
69	Mooring Equipment	.2136
71	Safety Requirements	1.8474
Sub-total	Machinery Items	.4717
39	Quarters Outfit	.7208
67	Heating, Ventilation & Air Conditioning	.8571
79	Electrical Systems	.3198
81	Blasting and Painting	.2981
83	Piping Systems	.2810
Sub-total	Outfitting Items	.3495
Total	All Items	.2682
Sub-total	Preliminary and Staff Items	.6722
Sub-total	All Steel Items	.2402
Sub-total	All Outfitting Items	.3631
TOTAL	All Items	.2682

EXHIBIT IV-8

COMPARISON OF ACTUAL FIRST SHIP MATERIAL COSTS

(RATIO OF IHI ACTUAL COSTS TO LSCO ACTUAL COSTS)

ITEM #	DESCRIPTION	RATIO
00	Contractual Costs	2.5531
03	Building Ways and Launching	.3980
05	Mold Loft	-
06	Warehousing	-
07	Construction Services	-
08	Clean Up	-
09	Testing and Inspection	.1400
11	Insurance, Christening, etc.	.1433
Sub-total	Preliminary Items	1.1312
01	Engineering	.0763
02	Planning and Production Control	-
85	Supervision	-
Sub-total	Staff Items	.0731
13	Hull Bottom	.7452
15	Hull Bulkheads and Framing	.8267
17	Hull Sides and Attachments	.7288
21	Hull Decks and Flats	.6861
23	Hull Inner Bottom	.9423
27	Bulworks and Windbreaks	1.6752
37	Deckhouses	.4719
87	Steel Scrap	-
89	Welding Supplies	.9155
Sub-total	Hull Steel Items	.7767
19	Miscellaneous Hull Structure	.6278
25	Foundations and Tanks	.5508
33	Deck Fittings	.1346
35	Ladders below Deck	.2575
55	Ladders above Deck	.5888
73	Doors and Hatches	.6283
75	Benches and Shelving	.1643
77	Awnings	.4565
Sub-total	Minor Steel Items	.5752
29	Sternframe and Sterntube	.6935
31	Rudder	.9457
45	Port Lights and Windows	.7279
57	Derricks and Cranes	.8863
61	Steering Systems	.7312
63	Propellers and Shafting	.8662
65	Machinery and Equipment	.6411
69	Mooring Equipment	.6051
71	Safety Requirements	.5718
Sub-total	Machinery Items	.6589
39	Quarters Outfit	.5320
67	Heating, Ventilation & Air Conditioning	.4006
79	Electrical Systems	.7794
81	Blasting and Painting	.4648
83	Piping Systems	.5133
Sub-total	Outfitting Items	.5584
Total	All Items	.6506
Sub-total	Preliminary and Staff Items	.5384
Sub-total	All Steel Items	.7169
Sub-total	All Outfitting Items	.6208
TOTAL	All Items	.6506

4.5 Analysis of Learning Curve Effects (Step P)

After adjustment for the impact of front-end-loaded items, the expected ratio of second-ship production manhours to first-ship production manhours is about 92%. Almost all of this improvement is in outfitting: the separate ratios for steelwork and outfitting are 98% and 82%.

The effect of this improvement is to bring second-ship total manhours to 99% of total estimate. Within this figure, however, steelwork hours will still be 17% over the estimate.

If this 92% improvement correctly reflects the first point on a "learning curve" the third ship can be expected to result in a further improvement of about 4%, rather than the cautious 1% shown in the projection of Exhibit IV-9.

EXHIBIT IV-9

COMPARISON OF FOLLOW SHIP TO FIRST SHIP MANHOURS

ITEM #	DESCRIPTION	SECOND SHIP	THIRD SHIP
00	Contractual Costs	1.0000	.9500
03	Building Ways and Launching	.7205	.6845
05	Mold Loft	.1749	.1662
06	Warehousing	.9623	.9178
07	Construction Services	.8753	.8238
08	Clean Up	.7694	.7694
09	Testing and Inspection	.8500	.8500
11	Insurance, Christening, etc.	1.0000	.9500
Sub-total	Preliminary Items	.7372	.7196
01	Engineering	.1085	.1085
02	Planning and Production Control	.5511	.5201
85	Supervision	.8432	.8076
Sub-total	Staff Items	.5478	.5247
13	Hull Bottom	.9943	.9943
15	Hull Bulkheads and Framing	1.0015	1.0015
17	Hull Sides and Attachments	.9776	.9776
21	Hull Decks and Flats	.8163	.8163
23	Hull Inner Bottom	1.1290	1.1290
27	Bulworks and Windbreaks	.9502	.9502
37	Deckhouses	1.0239	1.0025
87	Steel Scrap	-	-
89	Welding Supplies	.8026	.8026
Sub-total	Hull Steel Items	.9974	.9953
19	Miscellaneous Hull Structure	.9353	.9353
25	Foundations and Tanks	.8004	.7604
33	Deck Fittings	.8017	.8017
35	Ladders below Deck	.9515	.9515
55	Ladders above Deck	.8663	.8663
73	Doors and Hatches	.8481	.8481
75	Benches and Shelving	.7983	.7983
77	Awnings	-	-
Sub-total	Minor Steel Items	.8485	.8340
29	Sternframe and Sterntube	.9406	.9406
31	Rudder	.8963	.8963
45	Port Lights and Windows	.8319	.8319
57	Derricks and Cranes	.9143	.9143
61	Steering Systems	.8333	.8333
63	Propellers and Shafting	.9926	.9926
65	Machinery and Equipment	.8306	.8306
69	Mooring Equipment	.8419	.8419
71	Safety Requirements	.7874	.7874
Sub-total	Machinery Items	.8718	.8718
39	Quarters Outfit	.8483	.8483
67	Heating, Ventilation & Air Cond.	.7602	.7602
79	Electrical Systems	.8940	.8940
81	Blasting and Painting	.7791	.7791
83	Piping Systems	.7961	.7961
Sub-total	Outfitting Items	.8092	.8092
Total	All Items	.8182	.8096
Sub-total	Preliminary and Staff Items	.6235	.6026
Sub-total	All Steel Items	.9820	.9787
Sub-total	All Outfitting Items	.8161	.8161
TOTAL	All Items	.8182	.8096